U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF SYSTEMS DEVELOPMENT
TECHNIQUES DEVELOPMENT LABORATORY

TDL OFFICE NOTE 88-3

RESULTS OF A SURVEY ON THE USE OF STATISTICAL GUIDANCE BY FIELD FORECASTERS

Eli Jacks

June 1988

RESULTS OF A SURVEY ON THE USE OF STATISTICAL GUIDANCE BY FIELD FORECASTERS

Eli Jacks

1. INTRODUCTION

Since 1968, the National Weather Service (NWS) has provided field forecasters with short range (1-2 day) objective forecasts of sensible weather elements. This guidance relies on numerical weather prediction output variables produced by the National Meteorological Center (NMC) and statistical prediction equations developed by the Techniques Development Laboratory (TDL). Statistical guidance based on the Model Output Statistics (MOS) approach (Glahn and Lowry, 1972) first became available in 1969. By 1976, a complete MOS system for the Limited-area Fine Mesh (LFM) model (Gerrity, 1977; Newell and Deaven, 1981) was operational. This system has been revised and augmented over the years and still serves as the primary source of statistical guidance for short-range forecasting.

In addition to developing and maintaining statistical guidance products, TDL assists forecasters to effectively use the products by conducting workshops at local offices, preparing forecaster-oriented training materials, and disseminating information related to the performance of the guidance. TDL distributed a survey to NWS forecasters in September 1987 to assess the value of these training efforts, and to determine how much the guidance products are used and how well they are understood. Although the survey was geared toward the LFM-based MOS system, we also expected some comments on the perfect prog guidance (National Weather Service, 1987) based on the Nested Grid Model (Phillips, 1979). This new guidance system was implemented about 4 months prior to distribution of the survey. We hoped to answer the following questions from the survey results:

a. How is the guidance being used?

b. Is documentation of the guidance appropriate and useful?

c. Are forecasters in need of additional training regarding the use of the statistical guidance? If so, what form should such training take?

d. Is information about the statistical guidance accessible to forecasters?

The survey results are presented in this paper. A brief description of the manner in which the survey was developed and circulated is found in Section 2. Results from the analysis of the completed surveys are given in Section 3. Section 4 summarizes these results. Future plans are mentioned in Section 5.

2. DEVELOPMENT AND CIRCULATION OF THE SURVEY

The field forecaster survey for Weather Service Forecast Offices (WSFO's) was conceived in January 1987. A draft of the survey was reviewed by the NWS Eastern, Southern, Central, and Western Scientific Services Divisions (SSD's); the Services Evaluation Branch of the Office of Meteorology (OM); and the Line Forecasters Technical Advisory Committee (LFTAC) before being finalized and

distributed to field offices. About 550 surveys were sent out in September 1987 (either directly or through the SSD's) to be completed by forecasters at the 47 WSFO's throughout the contiguous United States. The Southern and Western Region SSD Chiefs also distributed copies to Weather Service Offices (WSO's); to offices responsible for the production of specialized aviation and agricultural forecast products; and to WSFO San Juan. Altogether, 280 completed surveys were returned to TDL between October and December 1987. It should be noted here that, with the exception of Question 1, not all forecasters responded to all questions. Thus, the sum of the responses for a particular question may not equal the total number of surveys returned. In addition, completing the survey was optional, and some forecasters may have been reluctant to voice their opinions.

Fig. 1 shows which regions (or groupings) responded most to the survey. Both the actual number of surveys received and the percentage of the total received from each grouping are given. Of the WSFO's, the most surveys were received from the Central Region, followed by the Southern, Eastern, and Western Regions, respectively. At least one survey was received from 43 of the 47 WSFO's. Surveys from WSO's in the Southern and Western Region were counted together in Fig. 1, while those from aviation and agricultural meteorologists and from WSFO San Juan were grouped in the "others" category. Because there is no statistical guidance system for Puerto Rico, these surveys will not be referred to further, except to note that most forecasters at San Juan requested that statistical guidance be developed for their area. Since the number of WSFO's varies by region, the average number of surveys returned per WSFO was also calculated (Fig. 2).

3. ANALYSIS OF RESULTS

Fig. 3 shows the first question of the survey. Here, forecasters were asked to rate on a scale of one to five how often they "use" each available LFM-based MOS forecast element in the preparation of the local forecast. A response of one corresponded to "rarely used", while five corresponded to "often used". It was meant that "use" be interpreted as "look at for comparison purposes in the formulation of the local forecast." Although some forecasters indicated that there were other possible interpretations of "use" in this context, the majority of those who raised this issue also indicated that they eventually interpreted the question as intended.

All of the forecast elements listed in Question 1 except for "% sunshine" are found in the FPC product on AFOS (National Weather Service, 1983a) and are listed in the same order as they appear in the message. MOS sunshine guidance is routinely available via AFOS and DIFAX, but as a graphic product only. It became obvious during our analysis that there was some confusion on this point, as 40 forecasters indicated that they did not realize MOS guidance for sunshine was available. Forecasters are encouraged to refer to Technical Procedures Bulletin (TPB) No. 334 (National Weather Service, 1983b) for more details on this topic.

Results of the quantitative analysis of Question 1 for WSFO's in the Eastern, Southern, Central, and Western NWS Regions are found in Figs. 4-7, respectively. Results for all 47 WSFO's combined are presented in Fig. 8, while results for all WSO's combined are given in Fig. 9. For ease of description, each of these groupings will be referred to as a "set" from this point on. Quantitative analysis was not carried out for surveys that fell into the

"others" category. For every element in each set, the mean response and standard deviation of the responses were computed. Note that PoP and max/min were the most widely used elements for all sets. The mean responses for PoP and max/min ranged from 4.5 to 4.9 for the WSFO's, which indicates that forecasters consistently make use of this guidance.

The results show that surface wind and 3-hourly temperature were also used often at WSFO's. The mean responses for wind ranged from 4.2 to 4.6, while the mean responses for 3-hourly temperatures ranged from about 4.2 in the East, Central, and South to 3.2 in the West.

The elements used either fifth or sixth most often, depending on the set, were 3-hourly dew point and clouds. The mean responses for 3-hourly dew point ranged from 3.2 in the West to 4.0 for the other WSFO sets. The mean responses for clouds ranged from 3.2 in the West to about 3.9 elsewhere. QPF guidance was used least in the West (mean response of 2.7) compared to the other WSFO sets (mean responses of 3.2 to 3.3). Best category guidance for ceiling and visibility (C/V) were the remaining elements for which usage nationwide exceeded the "sometimes" level ($\geq$ 3.0). Usage of the MOS guidance for TSTM, PoPT, PoSA, CIG, VIS, OBVIS, and % sunshine all averaged less than "sometimes" nationwide. The least used elements were OBVIS and % sunshine; however, the caveat mentioned before regarding the interpretation of responses for % sunshine should be noted.

To evaluate the overall usage of the MOS guidance in each region, the responses obtained for all elements were averaged and compared. Overall, forecasters in Western Region WSFO's and WSO's responded similarly, with an overall mean of 2.8, versus 2.7 for the WSO's. Forecasters at Southern Region WSFO's responded with an overall mean usage of 3.2, while Central and Eastern Region mean responses were 3.5.

Fig. 10 shows the second question of the survey, which consists of two parts. In part A, forecasters were asked whether the TPB's that describe the statistical guidance are clearly written and informative, and how the documentation written by TDL personnel might be improved. In part B, forecasters were asked to list any concepts related to the statistical guidance that require further explanation. All surveys were considered in the analysis of this question.

As can be seen in Fig. 11, nearly 160 forecasters thought that the written documentation is clearly written and informative. A response was assigned to the "no" category if the respondent indicated that the TPB's are too technical (e.g., contain too much emphasis on statistical derivation procedures) and/or do not contain enough examples of operational performance. A considerable number of forecasters mentioned that TPB's either are unavailable in their office, or are so difficult to find that they are effectively unavailable.

There were three common suggestions as to how TPB's could be improved. First, it was suggested that a summary page describing the most important operational considerations be included for easy reference. The other suggestions were that explanations be kept brief and simple, and that examples of case studies be included. The most common question generated by Question 2B was: "What are the important terms in the MOS equations for the stations in my area?" The second most common group of questions related to how the

statistical equations account for the influence of seasonal climatic changes, local terrain, or nearby bodies of water. There were 26 questions which fell into one of these categories nationwide. Questions on the use of surface observations as predictors in the statistical equations (particularly snow cover) appeared 13 times. Finally, a few forecasters had questions concerning the timing of seasonal changes in the MOS forecast system.

Fig. 12 shows the third question of the survey, which asked forecasters if they noticed anything about the statistical guidance that might be of interest to TDL or to other forecasters. The answer was a resounding "yes", as over 65 distinct categories of comments were subjectively assigned. In fact, there was more forecaster response to this question than to any other. As with the other questions, there were some comments which appeared more often than others. A list of the 10 most common observations, along with the number of times each occurred, is provided in Fig. 13. Not surprisingly, eight out of the top 10 observations in Fig. 13 relate directly to either the max/min or PoP guidance.

Fig. 14 shows the fourth question of the survey. Here, forecasters were asked to list research ideas that related to the statistical guidance. Over 70 different categories of ideas were subjectively assigned. The six suggestions which appeared three or more times are listed in Fig. 15. The most popular suggestion (made by 27 forecasters) was to provide more information on how the new NGM-based perfect prog system performs relative to the established LFM-based MOS system. In addition, nine forecasters specifically requested that max/min errors during shallow cold air events be studied. Forecasters also suggested that the ability of MOS to handle the dissipation of low clouds and fog should be investigated.

Figs. 16 and 17 show the final question of the survey, consisting of four parts. Results were determined for each grouping of stations. Our goals were:

a. to obtain information on how often forecasters have questions relating to the statistical guidance,

b. to find out what forecasters do to get answers to these types of questions, and

c. to determine whether forecasters are effectively using the communications network established for this purpose.

Question 5A utilizes a scale similar to that used in Question 1, asking forecasters to rate how often they had questions which could not be answered by other personnel in their office. The scale ranges from 1 for "rarely or never" to 5 for "rather often." The results of Question 5A are shown in Fig. 18.

Question 5B asked forecasters to describe how (and if) they have obtained answers to their questions and to evaluate how successful their approach has been. An approach was subjectively assigned to the "successful" category if the forecaster indicated that it has worked effectively at least occasionally. If a forecaster indicated that he/she was dissatisfied with a particular approach, it was counted as "unsuccessful." The approach most often mentioned was looking in the TPB's for answers. The majority of the forecasters (60) who gave this response indicated that they generally were able to obtain the

information desired by using this approach. Only seven forecasters indicated that this approach has not worked well for them. The next most popular approach was to seek answers from their SSD. Out of 38 forecasters, only one rated the experience as unsuccessful, although some of the forecasters who have been generally satisfied commented that the process of obtaining answers via this avenue sometimes took a considerable amount of time. A dozen forecasters have called TDL directly with their questions and have been satisfied with the results. Confusion about the distinction between TDL and NMC surfaced here, as some forecasters described calls they made to NMC in order to obtain answers to questions relating to the LFM or NGM.

Question 5C asked forecasters to rate the effectiveness of the existing communication system on a scale of 1 (ineffective) to 5 (very effective). The mean response for each set generally fell close to the "moderately effective" range, although a slightly lower value applied to the WSO's as a group.

Question 5D solicited suggestions on how communications lines for obtaining answers to questions about the statistical guidance could be improved. The responses to this question are summarized in Fig. 19. The most popular suggestion was to provide a phone number that forecasters could use to call and talk to TDL personnel directly. Another popular suggestion was that additional training materials on the use of statistical guidance be developed, either in the form of a handbook or a videotape. Many forecasters requested that more case studies on the statistical guidance be provided to the field and that station visits by TDL personnel continue. Another suggestion further supports the conclusion that some forecasters are unclear about the distinction between TDL and NMC. Over a dozen respondents indicated that they have not been hearing about changes in the "models" soon enough. The models referred to, however, were often the NGM or LFM.

There were a few other comments made by forecasters which are noteworthy. The most important of these relates to forecaster perception of role of the verification system in the NWS. There were 11 forecasters who fear that if MOS outperforms them, they will be replaced. Hence, they are reluctant to deviate substantially from MOS. Also, seven forecasters mentioned that the survey was a good first step towards the goal of improving communications between the field and NWS Headquarters.

4. CONCLUSIONS

The results from Question 1 suggest that the LFM-based MOS guidance is used most often at Eastern and Central Region WSFO's, somewhat less often at Southern Region WSFO's, and quite a bit less often at Western Region WSFO's and at the WSO's. For all sources considered in Question 1, max/min and PoP are the forecast elements most often used, followed by wind and 3-hourly temperature, and then by clouds and 3-hourly dew point. MOS sunshine guidance is used least often, but this could be due to the fact that many forecasters are not well informed as to the nature or even the existence of this product. The guidance for obstructions to vision is also not used often.

Over 80% of all respondents indicate that the documentation of the statistical guidance provided by TDL is generally clear and well written. Those who have not been satisfied would like to see more examples on how to apply the products described in TPB's, and/or a reduction in the amount of technical information presented.

There is strong evidence that forecasters would appreciate additional training materials relating to the use of statistical guidance. For example, many forecasters have questions about the terms included in the statistical equations for their station, while others want to know more about the distinction between MOS and perfect prog. Two common suggestions were that case studies on the performance of the statistical guidance during important weather events be provided and that situations where MOS and perfect prog guidance disagree be analyzed. Also, periodic trips by TDL personnel to field offices and the production of a videotape or handbook on the basics of statistical forecasting were encouraged.

Most forecasters seem satisfied with the available communications channels for receiving information or getting answers to questions relating to the statistical guidance. The approach most often used by forecasters is looking in the TPB's, although the SSD's are often used successfully as a source of information. Other forecasters have called TDL directly with their questions. Some forecasters indicated that TPB's are either difficult to locate in their office or are not available at all.

5. FUTURE PLANS

Overall, forecaster response to the survey was enthusiastic and thorough. We were impressed not only by the number of surveys returned, but by the amount of time forecasters took to express their thoughts. It is clear, therefore, that forecasters are interested in learning more about the statistical guidance. TDL will be sending an informational package to each WSFO in response to the survey. The package will contain answers to the questions most often asked and will address many of the concerns raised by individual forecasters.

The results from Question 2A support the conclusion that the majority of forecasters are generally satisfied with the TPB's. It is our goal that TPB's be written in a format that is easy to read and understand. Many TPB's written by TDL personnel contain an "Operational Considerations" section, which outlines the strengths and weaknesses of the guidance, as well as other information of direct interest to the forecaster. In addition, we will provide a summary page in future TPB's.

In February 1988, a videotape on the statistical guidance was produced by TDL at the request and with the assistance of OM. This tape reviews the basics of statistical guidance and contains case studies that highlight some of the strengths and weaknesses of the MOS and perfect prog guidance systems. The tape is organized into four sections so that it is not necessary to absorb all of the material at one viewing. Exercises to be done at the end of the first three sections are provided to help forecasters decide where they might need additional review. This tape has been distributed to WSFO's throughout the contiguous United States, Alaska, and Hawaii.

Many of the questions raised by forecasters in Question 2B will be addressed in the mailing. Printouts of the operational equations will be sent to those forecasters who requested them. In addition, we think that the videotape will answer some of the questions raised by the forecasters. The results from Questions 1 and 3 indicate that forecasters seem to look most closely at the max/min and PoP guidance, although interest is by no means limited to these two elements. We plan to perform case studies when interesting situations arise.

In particular, we will continue to evaluate the performance of the perfect prog guidance relative to MOS. Forecasters are strongly encouraged to join us in this effort, as they are most aware of the local effects which can cause problems in the statistical guidance for their area. The suggestions to develop guidance for additional sites will be considered when we develop future guidance systems.

6. ACKNOWLEDGMENTS

I would like to thank Gary M. Carter for supporting the concept of this survey and for his guidance throughout the process. Thanks are also due to the SSD's and to the Area Managers for their support in the distribution of the surveys. Karen Yip is acknowledged for typing the manuscript. Finally, thanks to the field forecasters who took the time to thoughtfully complete and return the surveys.

REFERENCES

Gerrity, J. P., Jr. 1977: The LFM model-1976: A documentation. NOAA Technical Memorandum NWS NMC-60, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 68 pp.

Glahn, H. R., and D. A. Lowry, 1972: The use of Model Output Statistics (MOS) in objective weather forecasting. J. Appl. Meteor., 11, 1203-1211.

National Weather Service, 1983a: The FOUS12 (FO12) bulletin. NWS Technical Procedures Bulletin No. 325, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 12 pp.

_____, 1983b: Sunshine and solar energy guidance. NWS Technical Procedures Bulletin No. 334, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 8 pp.

_____, 1987: Perfect prog maximum/minimum temperature, probability of precipitation, cloud amount, and surface wind guidance based on output from the Nested Grid Model (NGM). NWS Technical Procedures Bulletin No. 369, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 12 pp.

Newell, J. E., and D. G. Deaven, 1981: The LFM-II model--1980. NOAA Technical Memorandum NWS NMC-66, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 20 pp.

Phillips, N. A., 1979: The Nested Grid Model. NOAA Technical Report NWS 22, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 80 pp.

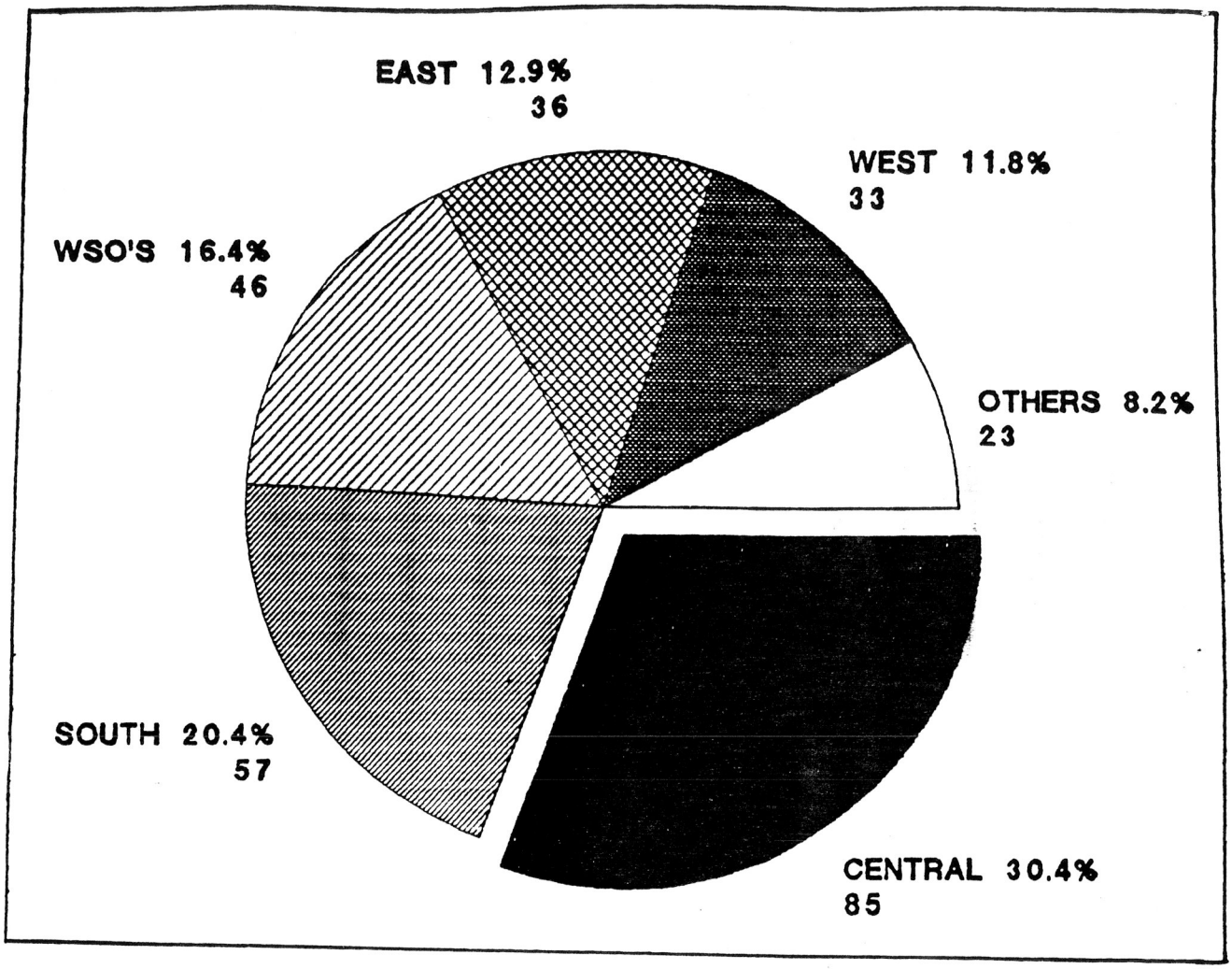


Figure 1. The number of surveys returned from each source and the percentage of the total returned that these numbers represent.

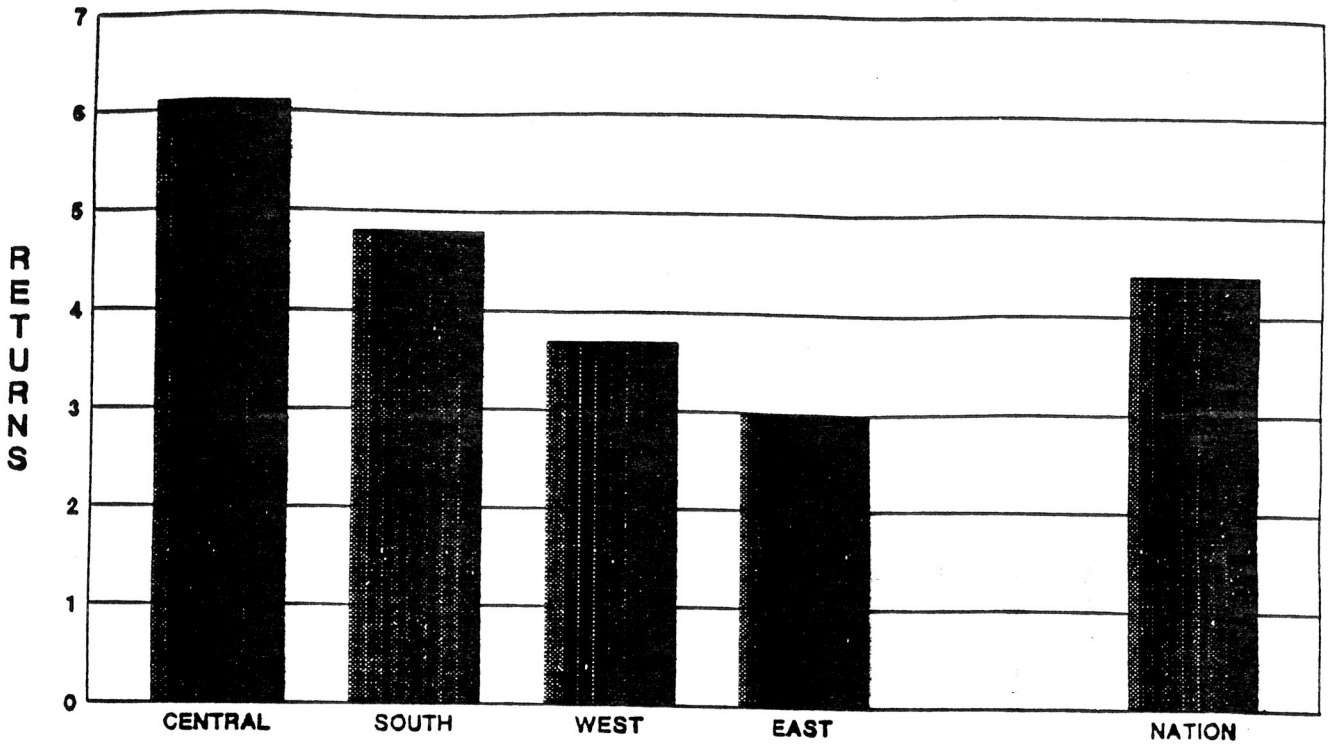
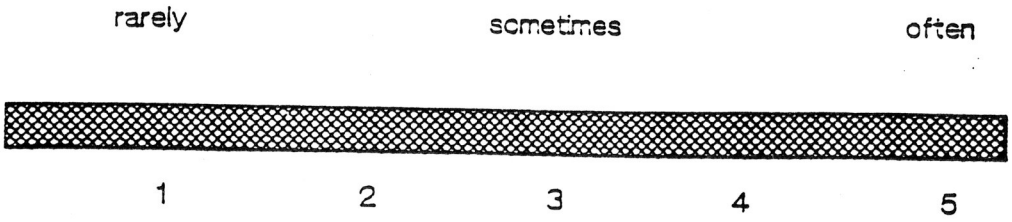


Figure 2. Mean number of surveys returned from each WSFO by NWS region and for the nation.

WSFO_____ NAME_____

1. FOR THE PURPOSE OF ASSESSING HOW YOU USE THE MOS GUIDANCE.

Please indicate how often you use each of the MOS forecast elements by referring to the scale below. Enter the appropriate number on the dashed lines provided.



ELEMENT LIST

POP	_____
QPF	_____
TSTM	_____
POPT	_____
POSA	_____
MX/MN	_____
TEMP	_____
DEWPT	_____
WIND	_____
CLDS	_____
CIG	_____
VIS	_____
C/V	_____
OBVIS	_____
% SUNSHINE	_____

Figure 3. The first question of the survey.

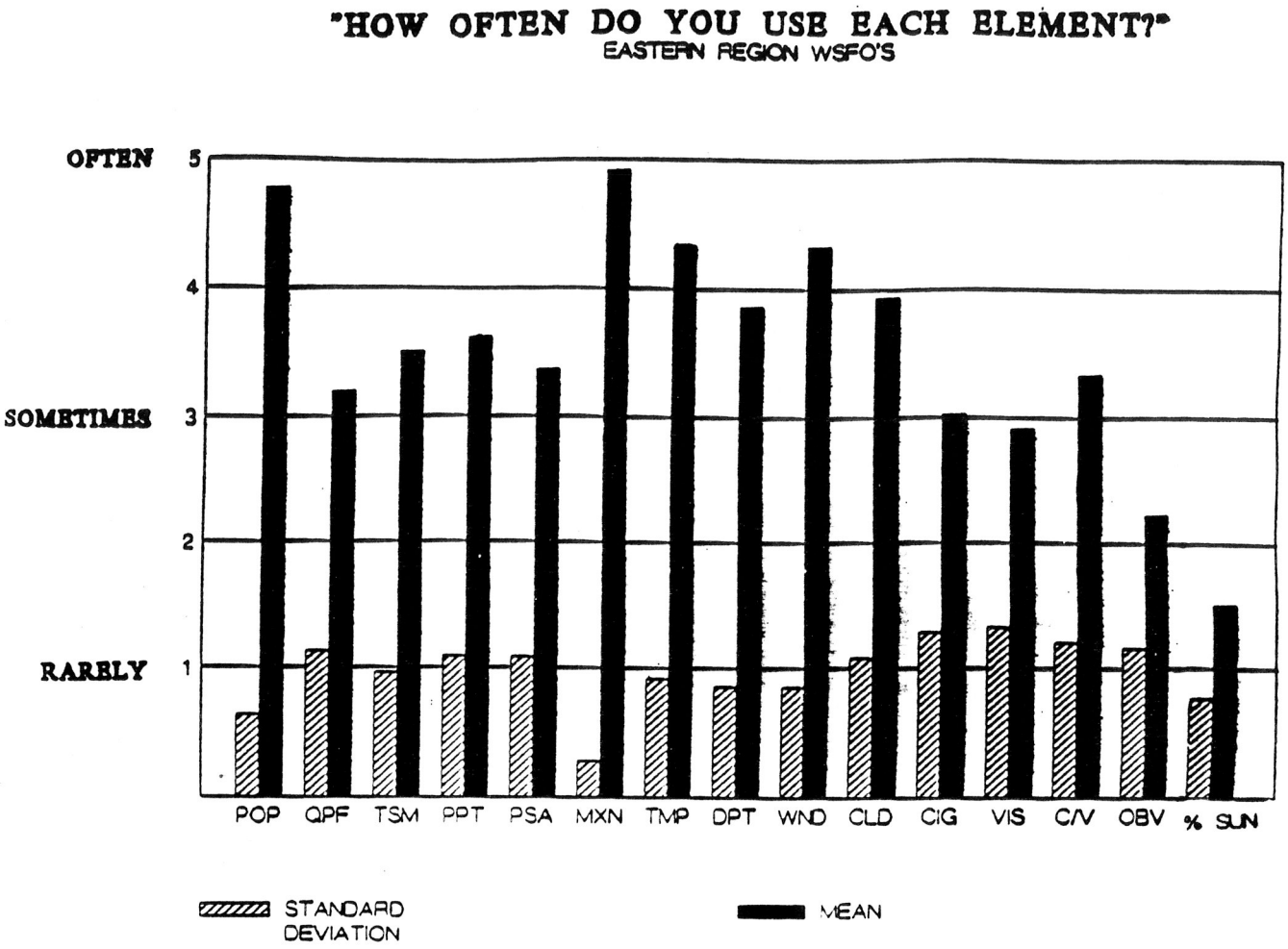


Figure 4. Results for the Eastern Region WSFO responses to Question 1. Mean usage and the standard deviation around the mean is shown for each MOS forecast element found in the FPC message and for % sunshine. With the exception of % sunshine, elements are listed in the same order (from left to right) as they appear in the FPC message.

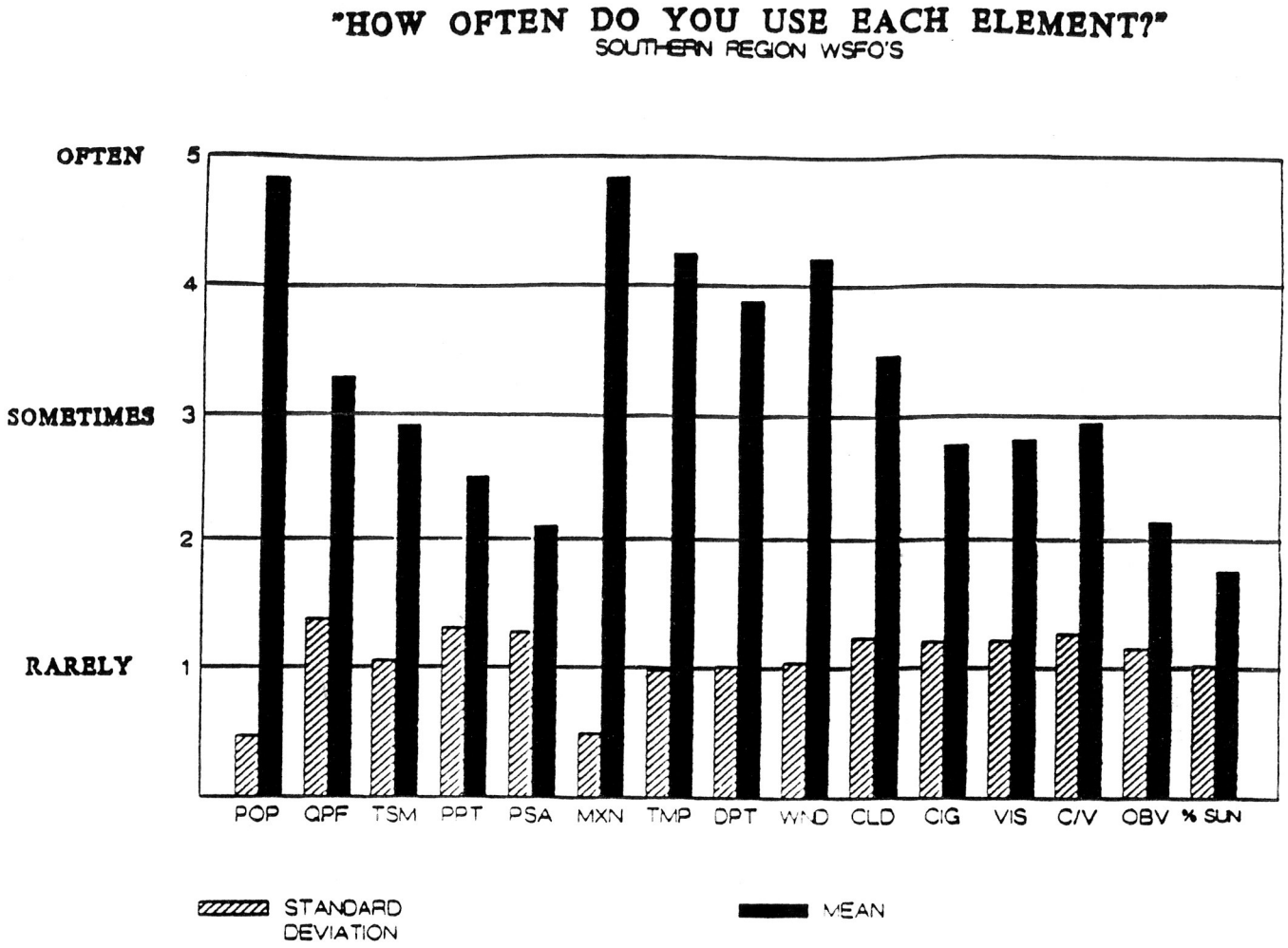


Figure 5. Same as Fig. 4 except for Southern Region WSFO's.

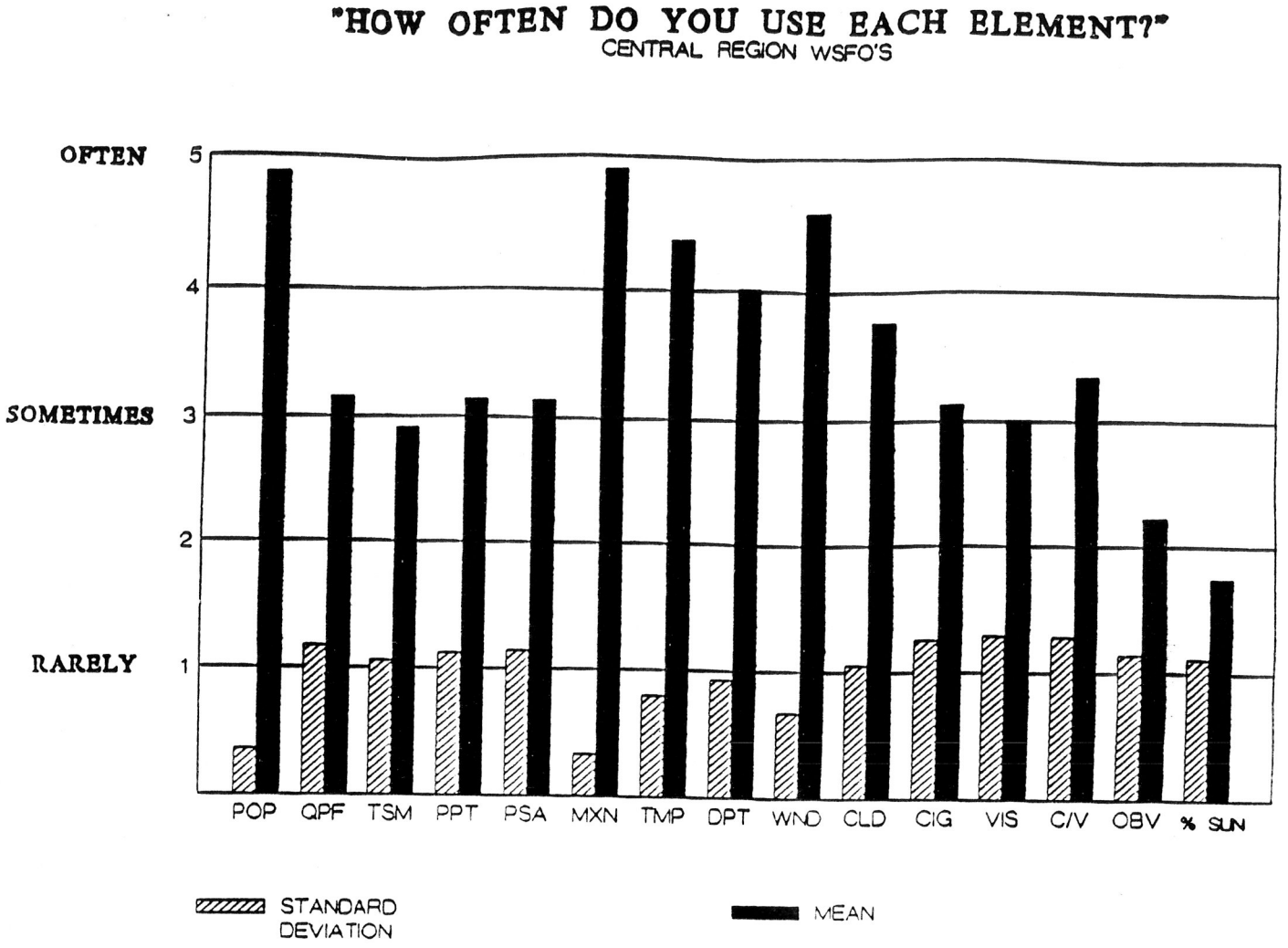


Figure 6. Same as Fig. 4 except for Central Region WSFO's.

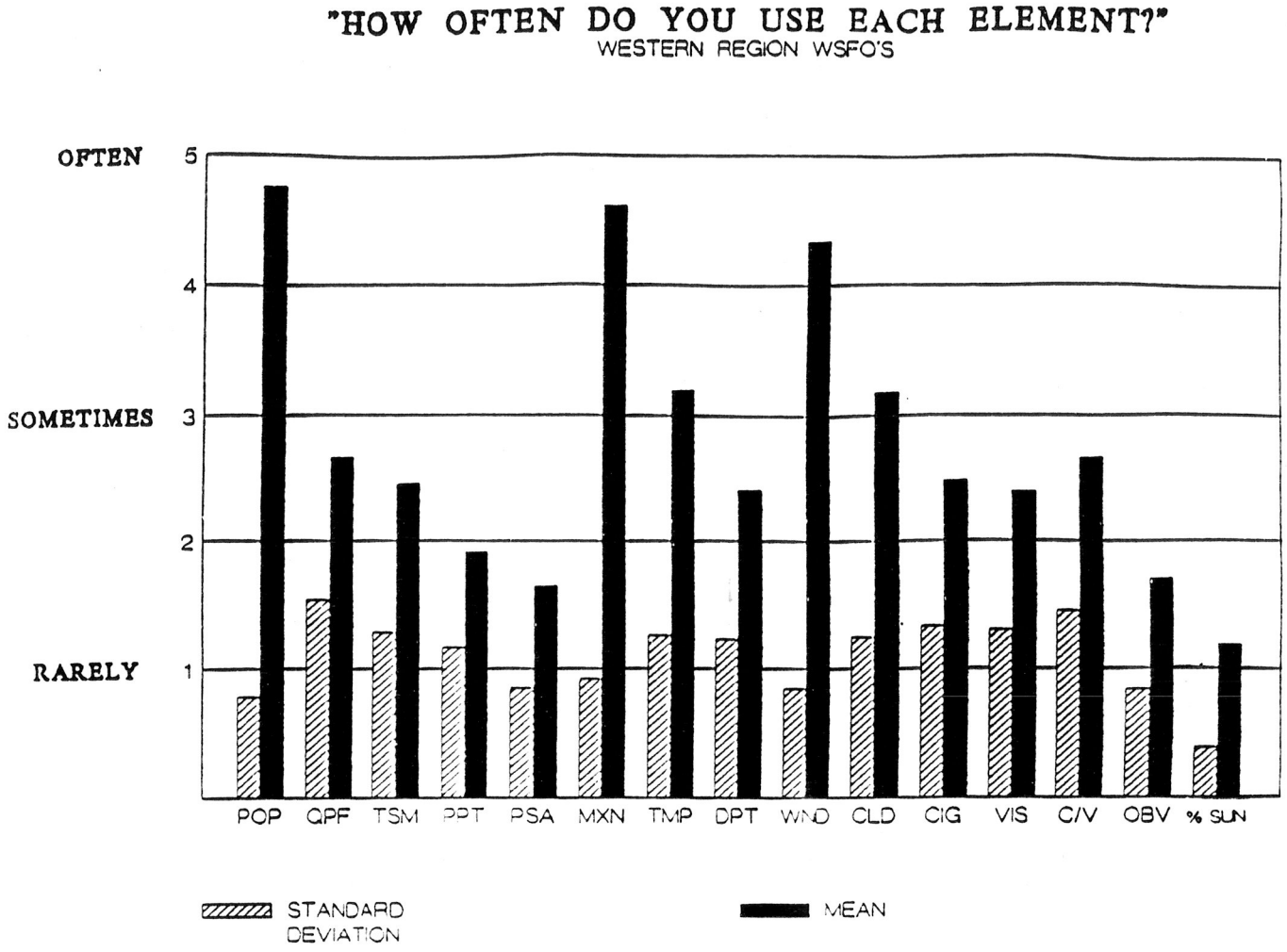


Figure 7. Same as Fig. 4 except for Western Region WSFO's.

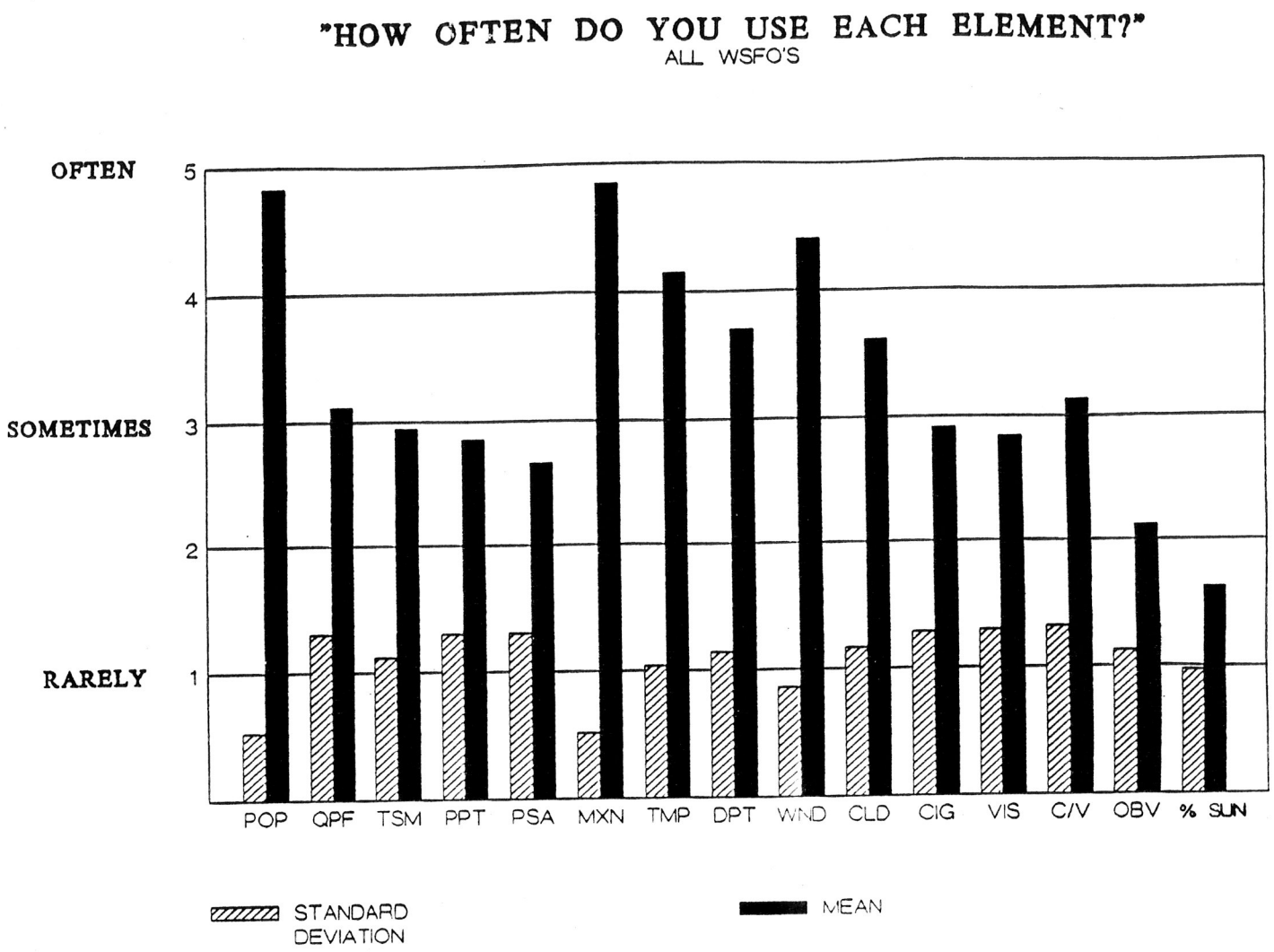


Figure 8. Same as Fig. 4 except for all WSFO's.

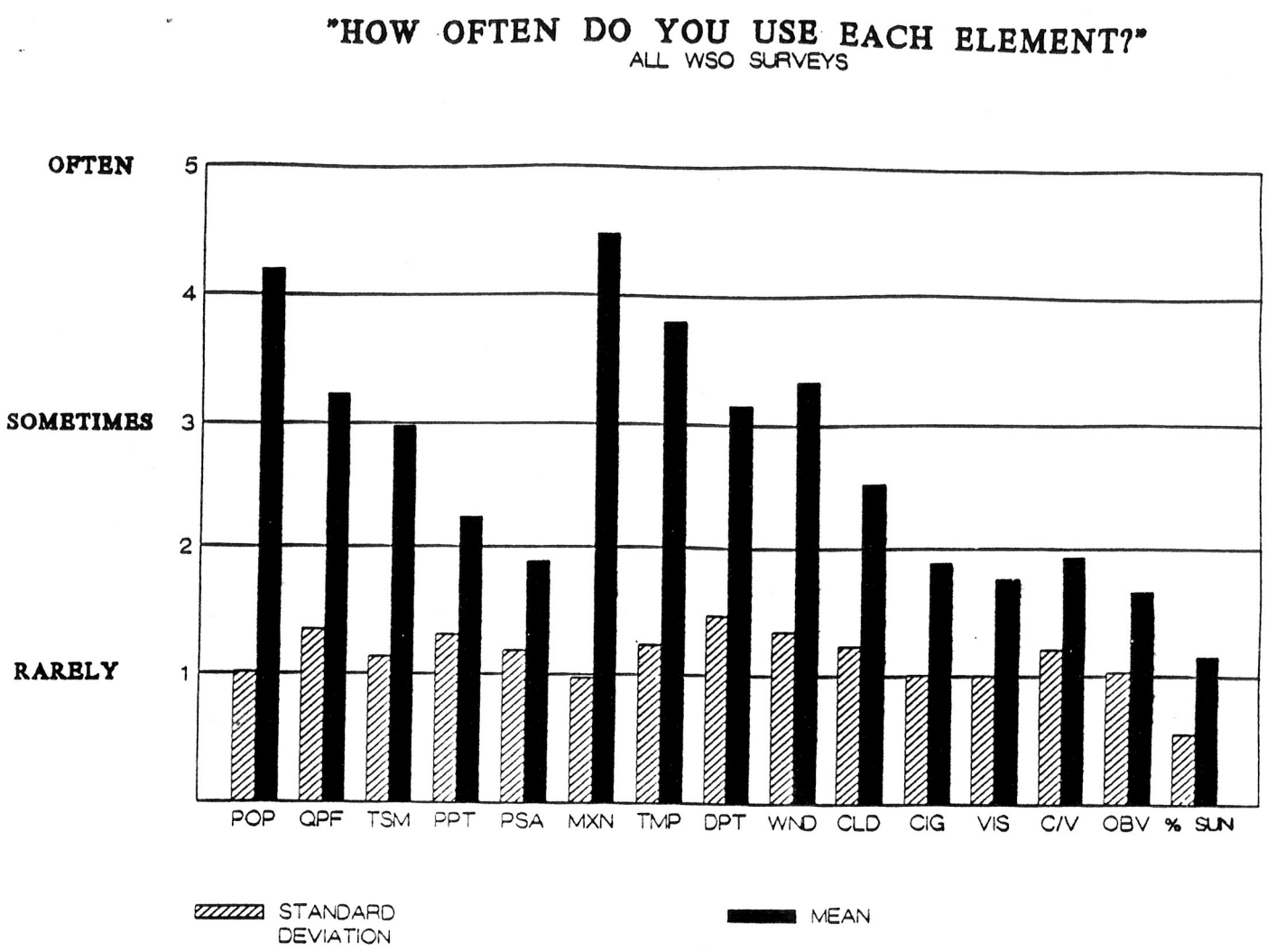


Figure 9. Same as Fig. 4 except for all WSO's.

WSFO_____ NAME_____

2. TO SOLICIT SUGGESTIONS ON HOW WE MIGHT IMPROVE OUR DOCUMENTATION:

A) In your opinion, are the Technical Procedures Bulletins and other documentation relating to the objective guidance clearly written and informative? If not, please list (as specifically as possible) any suggestions you have to improve the format of such written material.

B) If there are any concepts relating to the objective guidance in general you would like to better understand or if you have any specific questions about the equations at your station, let us know here.

SAMPLE QUESTIONS:

a) How well does the objective guidance account for the presence of local topographical features and for local climatology?

b) How do the predictors in perfect prog and MOS warm season PoP equations for the 24-h projection differ at my station?

Figure 10. The second question of the survey.

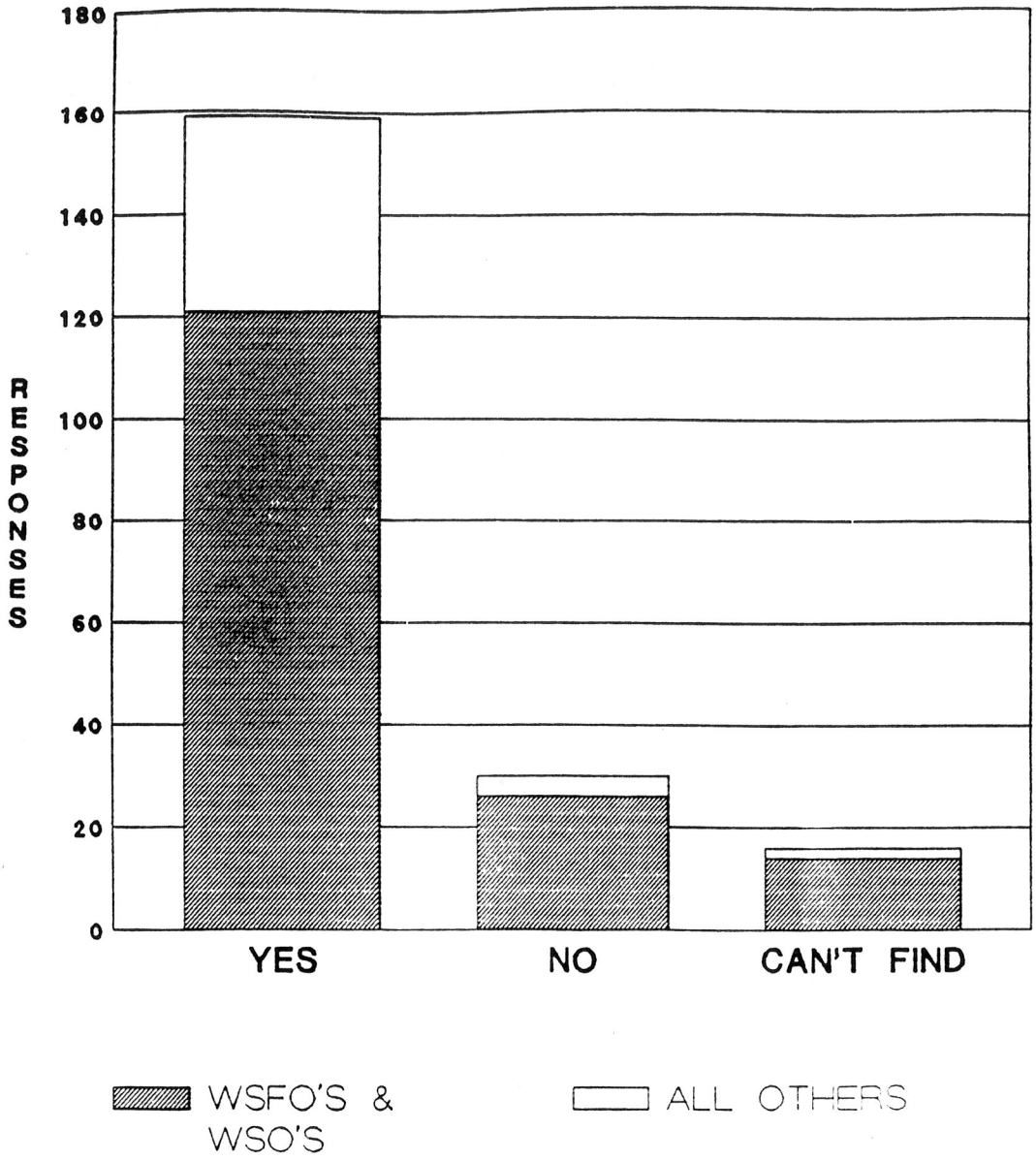


Figure 11. Response to the question: "...are the TPB's...clearly written and informative?" WSFO and WSO responses are considered as a unit. The number of respondents who could not locate documentation at their site is also depicted.

WSFO_____ NAME_____

3. SO THAT WE MAY BENEFIT FROM YOUR EXPERIENCE:

_____

If there is anything you have noticed about the statistical guidance at your station that you think might be of interest to us or to other forecasters, let us know here.

SAMPLE OBSERVATIONS:

a) You may already have noticed that there are syncptic situations where MOS seems to consistently outperform perfect prog, or vice-versa.

b) You may have developed a system by which you adjust the MOS temperature forecasts by a certain amount for elevated zones in your area of forecast responsibility.

Figure 12. The third question of the survey.

1.	MOS moves surface cold air out too quickly	(21)
2.	MOS often underforecasts wind speed	(21)
3.	MOS is often too warm during shallow cold air events	(17)
4.	MOS is often too close to climatology	(12)
5.	MOS is often too cold for the day following cold frontal passage	(9)
6.	Bias is noted during periods when ground is abnoramlly wet or dry	(9)
7.	Perfect prog POPS are better than MOS POPS	(7)
8.	MOS POPS forecast too many occurences of 20-30% (MOS has difficulty with starting and stopping precipitation)	(6)
9.	MOS is too warm and dry during upslope flow	(6)
10.	MOS PoPS are too low in the nation's midsection during Gulf of Mexico return flow situations	(6)

Figure 13. The 10 most frequent comments related to the performance of the statistical guidance. The number of times each comment occurred is given in parentheses. Observations from all surveys were considered.

WSFO_____ NAME_____

4. FOR THE PURPOSE OF SOLICITING YOUR RESEARCH IDEAS.

Here is your chance to list research ideas relating to the statistical guidance. Projects that you would like to do (or see done) could be either local in nature or could refer to a larger scale problem. Please be as specific as possible!

SAMPLE PROJECTS:

a) Test performance of MOS and/or perfect prog forecasts for specific elements during given synoptic situations at your location.

b) Study cases where MOS and perfect prog forecasts for a given element were radically different.

Figure 14. The fourth question of the survey.

1.	Provide more case studies of MOS versus perfect prog when significant differences occur	(27)
2.	Compare MOS versus perfect prog temperature forecasts during shallow cold air events	(9)
3.	Study the inability of MOS to handle fog and stratocumulus formation and breakup	(9)
4.	Develop guidance for additional locations	(6)
5.	Develop interactive program where forecasters could adjust equations based on situation	(3)
6.	Consider developing equations for sites other than the airport	(3)

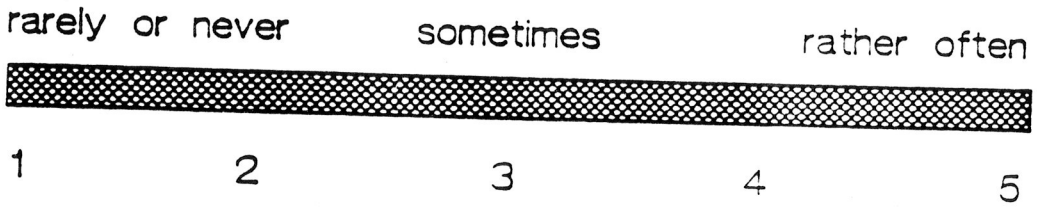
Figure 15. Research ideas that were suggested three times or more. Suggestions from all surveys were considered.

WSFO_____ NAME_____

5. FOR THE PURPOSE OF ASSESSING HOW WE MIGHT IMPROVE OUR RELATIONSHIP WITH YOU:

One of the major challenges facing a large organization such as ours is to maintain efficient and effective communications between the various units that make up the organization. Your responses to the following questions will help me to assess where we stand in this regard. Where appropriate, circle the number which best fits your answer on the scales provided.

a) How often have you had questions relating to the objective guidance which could not be answered by other personnel in your office?



(continued on next page)

Figure 16. The first page of the survey's fifth question.

b) If you have had the experience described in a), did you pursue the matter further (yes, no). If "yes", how did you go about trying to find out the answers to your questions?

Was this approach successful (yes, no)? Comments?

c) How effective do you feel the existing communication lines are for getting answers to your questions relating to the objective guidance?

ineffective moderately effective very effective

1 2 3 4 5

d) Any suggestions on how communications in this area might be improved?

Figure 17. The second page of the survey's fifth question.

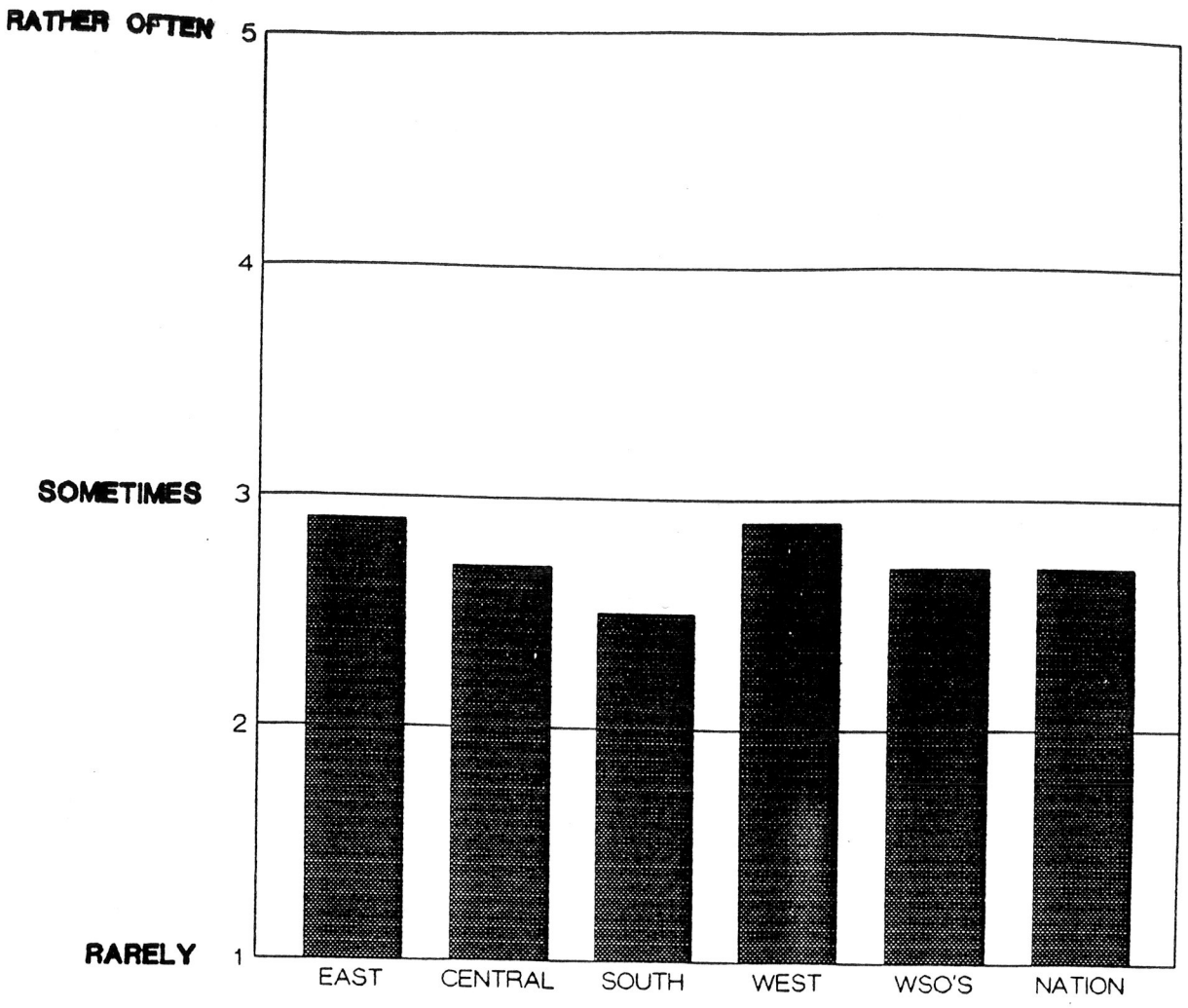


Figure 18. Response to the question: "How often have you had questions about the objective guidance which could not be answered by other personnel in your office?" Results for each grouping are shown separately.

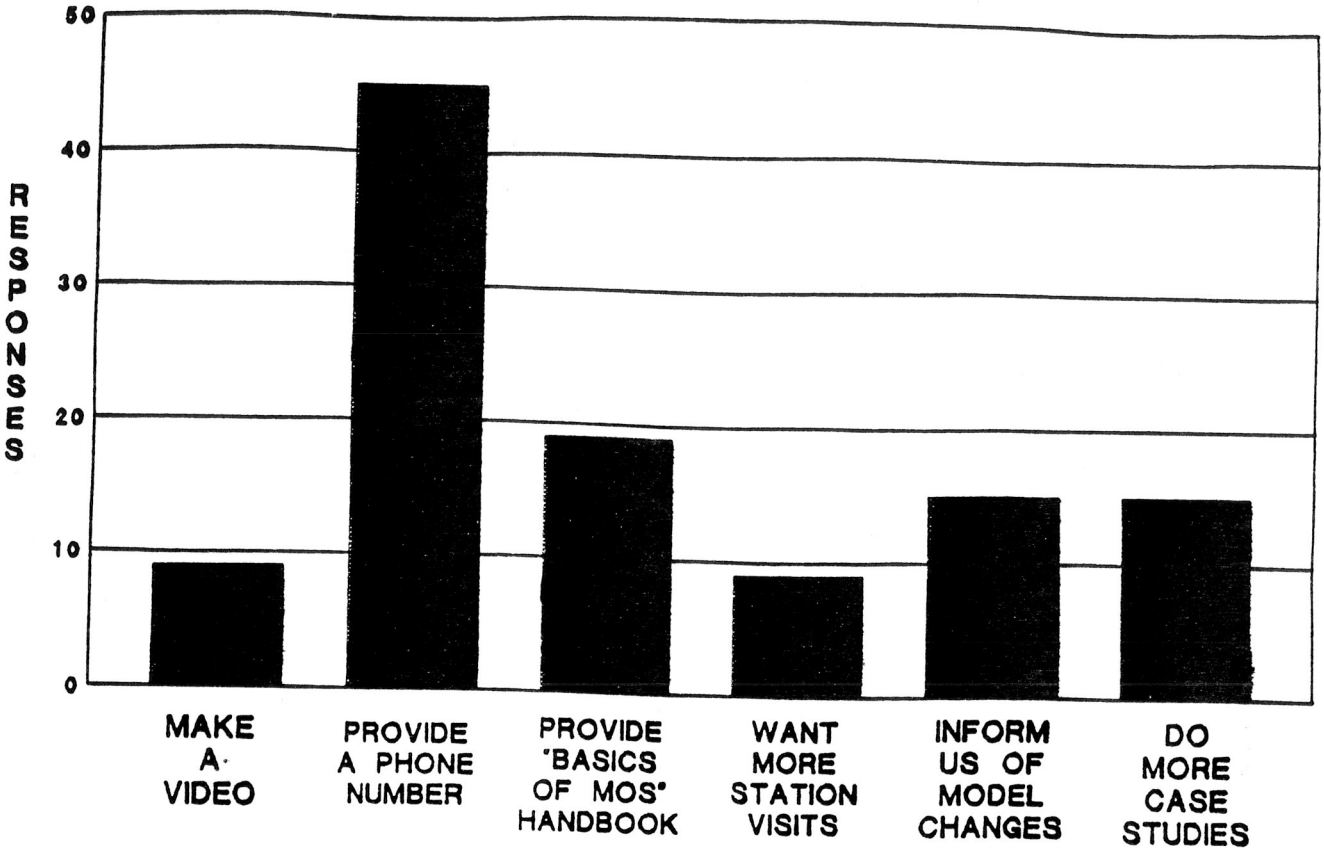


Figure 19. The most common suggestions on how communications could be improved, along with the number of times each idea was suggested. All surveys were considered.